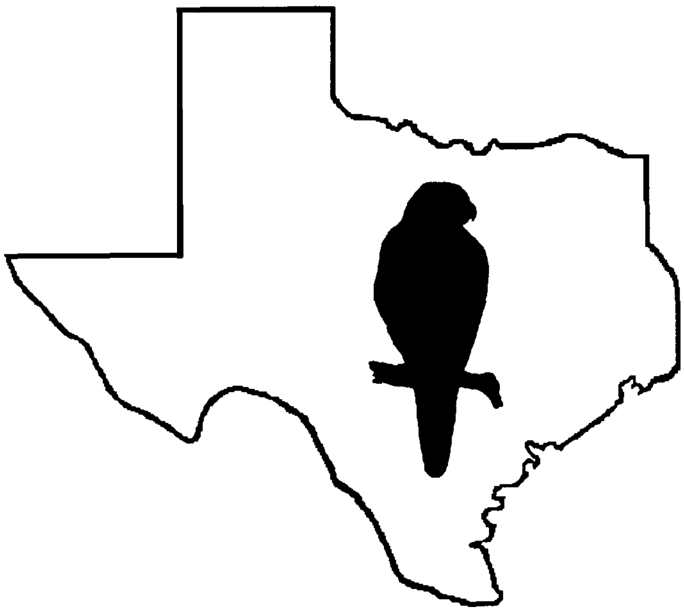
U.S. Fish and Wildlife Service
Region 2
Contaminants Program

Environmental Contaminants in Potential Prey of Aplomado Falcons in the Lower Rio Grande Valley, Texas

by

M. Clare Lee



U.S Fish and Wildlife Service
Corpus Christi Ecological Services Field Office
Campus Box 338, 6300 Ocean Drive
Corpus Christi, Texas 78412

June 1997

ABSTRACT

Reintroduction of the northern aplomado falcon (*Falco femoralis septentrionalis*) into its former range in Texas began in 1985, and continued with a full scale release of captive-bred falcons in 1993 on Laguna Atascosa National Wildlife Refuge (NWR). A study was conducted in 1994 to determine whether contaminants in falcon prey posed a threat to the successful recovery of the species. Meadowlark *(Sturnella* sp.), mourning dove (*Zenaida macroura*), cicadas, and dragonflies were collected from two areas on the Laguna Atascosa NWR and from two tracts on the Lower Rio Grande Valley NWR where falcons may disperse. Organophosphate pesticides and PAH's were below detection levels in all samples. With the exception of DDE, all other organochlorine pesticides were also below detection. Mercury concentrations in meadowlark were above levels in prey that have been associated with reproductive anomalies in sensitive aquatic birds, so there may be some concern about reproductive or chronic effects in the aplomado falcon from this heavy metal.

Project number: 21410-1 130-2N19

INTRODUCI'ION

The historical range of the northern aplomado falcon (*Falco femoralis septentrionalis*) extends from Central America to southern areas of Arizona, New Mexico, and Texas. The aplomado falcon inhabits desert grasslands and coastal prairies, but disappeared from most of its U.S. range by the 1940s (USFWS 1990). Causes for the decline of the species include encroachment of woody vegetation, conversion of grasslands to farmland, pesticide contamination, both in the U.S. and in eastern Mexico (Kiff et al. 1980, USFWS 1990), loss of available nesting habitat, and loss of wetlands that support avian prey species (Hastings and Turner 1964). Prior to reintroduction attempts, the last reported nesting attempt in Texas occurred in 1941 (Hector 1981). In 1986, the aplomado falcon was listed as endangered by the U.S. Fish and Wildlife Service (51 CFR 6686; February 25, 1986).

A captive breeding program was initiated in 1977 at the Chihuahuan Desert Research Institute (Cade et al. 1991) and transferred to the Peregrine Fund in 1983 (Peregrine Fund 1994). Experimental releases began in Texas in 1985. After achieving a stable population of captive breeding pairs, a large number (26) were released in 1993 (Peregrine Fund 1994). Young falcons have since been introduced into hack sites on Laguna Atascosa National Wildlife Refuge (NWR) each summer and fed until they are mature enough to forage on their own. Following release, hack site attendants observe behavior and document success of the release until the birds disperse. To date, 130 falcons have been successfully released (Fernandez 1996). In 1995, a pair nested in Texas for the first time in over fifty years. One nestling successfully fledged but the other egg failed to hatch. The following year, two pairs nested and three young successfully fledged from one nest, the other nesting attempt was lost to predation (Fernandez 1996).

The Lower Rio Grande Valley is one of the most intensively farmed areas in the United States (USFWS 1986). Ninety-five percent of the native habitat has been cleared since the early 1900s, and the majority of that land is under agricultural production (Jahrsdoerfer and Leslie 1988). Runoff from cultivated fields may concentrate pesticides and herbicides in ponds and other permanent bodies of water. These permanent water bodies, including irrigation and stormwater drainage canals, are used extensively by wildlife (Chaney 1989).

On the U.S.-Mexico border, development has increased rapidly, including the operation of approximately 1400 maquiladoras (product assembly) plants. Increased economic growth has led to a surge in population along the border in the last 15 years. Much attention has been focused on water quality problems, especially the potential for toxic chemical contamination (IBWC 1994). In addition, oil and gas operations are common on both National Wildlife Refuge tracts and in the surrounding areas.

Aplomado falcon recovery plan objectives include monitoring contaminant residues in typical prey of aplomado falcons and identifying and reducing sources of pollution (USFWS 1990). The purpose of this study was to determine if prey of aplomado falcons are concentrating contaminants to potentially hazardous levels that may pose a risk to the health of the birds being released in the Lower Rio Grande Valley.

STUDY AREA

Laguna Atascosa NWR is a 48,597-acre refuge located adjacent to the Laguna Madre on the lower Texas coast. The Lower Rio Grande Valley NWR is a collection of tracts of land acquired with the long-term goal of creating a corridor for wildlife along the Rio Grande and in the Valley. Some of these tracts are small and surrounded by agriculture, and are frequently subject to overspray and drift from aerial applications of pesticides (USFWS 1986). Four sites were selected for this study (Figure 1):

1) Laguna Atascosa NWR, Site 1 (Unit 7)- located in the southern portion of the refuge
2) Laguna Atascosa NWR, Site 2 (Unit 2&3) - located on the west side of the refuge
3) Lower Rio Grande Valley NWR, La Selva Verde Tract - 2028.52 acres with a permanent conservation easement of 475.73 acres on the west side
4) Lower Rio Grande Valley NWR, Willamar Tract- 1087.22 acres.

METHODS

Birds such as doves, icterids, and cuckoos are the principal prey items for aplomado falcons comprising the majority of their dietary biomass in eastern Mexico (Hector 1985). Other prey include insects, small mammals, and reptiles (Hector 1985, 1981). Aplomados may be more insectivorous during the non-breeding season than during the breeding season (Hector 1985), as observed at Laguna Atascosa NWR where subadult falcons preyed heavily on dragonflies (Chris Perez, pers. comm., 1994).

Two bird species were selected that are resident, common, and typical prey of the aplomado falcon: the mourning dove (*Zenaida macroura*), a granivorous species, and the meadowlark (*Sturnella*), an omnivore, though primarily insectivorous. No effort was made to distinguish between the eastern and the western meadowlark (*Sturnella magna* and *S. neglecta*, respectively) as they both occur in the area. Five mourning doves and five meadowlarks were collected from three of the four sites. Due to difficulty in obtaining meadowlark at the La Selva Verde tract, northern bobwhite (*Colinus virginianus*) were collected in place of the meadowlarks. Birds were collected using a shotgun and stainless steel shot. Carcasses were immediately placed into whirl-pack bags, labeled, and placed on ice until processing in the lab. Whole bodies less the beak, tarsi, feathers, and digestive tract were composited by species and site and analyzed for the organic compounds listed in Table 1. Livers were also composited by species and site and analyzed for trace elements.

For the insect portion of the study, dragonflies and cicadas were collected. Depending on the species, dragonflies may live for up to five years in an aquatic larval stage before emerging (Swan and Papp 1972) and have the potential to be exposed to contaminated runoff. Cicada larvae spend their entire developmental period, which may take several years, in the soil, feeding on roots prior to emergence (Gillott 1980). They should, therefore, be good indicators of local contamination (Clark 1992). Dragonflies were collected from all four sites and cicadas were collected from all but the Willamar site. Both dragonflies and cicadas were captured in insect nets and placed immediately into chemically-cleaned jars and kept chilled. Due to limited sample size, insects were analyzed for organochlorine and organophosphate pesticides, PCBs, and polynuclear aromatic hydrocarbons (PAHs), but not for trace elements.

All samples were collected between June 7 and August 23, 1994. Mourning dove and meadowlark from Laguna Atascosa NWR were collected prior to the release of aplomado falcons from the hack sites. Following processing, all samples were frozen until sent to the analytical lab.

Bird samples were analyzed for PCBs, PAHs, and organochlorine pesticides at Mississippi State Chemical Laboratory. Organophosphate analyses were conducted at Patuxent Analytical Control Facility. Bird livers were analyzed for trace metals at Research Triangle Institute. PAHs were analyzed by capillary, flame ionization gas chromatography and fluorescence HPLC. Organochlorine and PCBs were quantified using electron capture gas chromatography. Organophosphate residues were determined using column gas chromatography with a flame photometric detector. With the exception of mercury, metals were detected by graphite furnace atomic absorption spectrometry (AAS). Mercury was determined by cold vapor atomic absorption. Blanks, spikes, duplicates, and standards were used for quality assurance and quality control (QA/QC). QA/QC was monitored by the Patuxent Analytical Control Facility. Trace element results are reported in µg/g dry weight (dw) and all other analytical results are reported in wet weight (ww).

RESULTS AND DISCUSSION

Aromatic Hydrocarbons and Organophosphates

Neither the PAHs nor the organophosphate pesticides listed in Table 1 were above the detection limit of 0.01 and 0.05 µg/g wet weight, respectively, in the bird tissue or insect samples.

Organochlorine Pesticides

None of the organochlorine pesticides listed in Table 1 were present except p,p'-DDE. Results for this DDT homolog are listed in Table 2. Concentrations of DDE ranged from below detection to 0.25 μg/g (ww)in bird tissues. The highest level was detected in meadowlark from the Willamar tract. DDE was also detected in one cicada sample and three of the four dragonfly samples. Dragonflies from La Selva Verde had the highest concentration (0.05 μg/g ww).

In the Lower Rio Grande Valley, DDE concentrations have been quite high in the past. Great-tailed grackles (*Quiscalus mexicanus*), also potential prey of aplomado falcons, collected near the Rio Grande had DDE residues that ranged from 4 to 24 μg/g. Residues were much higher in fish-eating birds; levels were detected up to 81 μg/g (White et al. 1983). A white pelican carcass (*Pelecanus erythrorhynchos*) had DDE residue of 46.1 μg/g (Gamble et al. 1988). In some areas, DDE concentrations acquired from local contamination continue to persist. Whiptail lizards (*Cnemidophorus* spp.) and western kingbirds (*Tyrannus verticalis*), both insectivorous, had elevated residues (White and Krynitsky 1986). In a more recent study (Henry 1992), the highest levels of DDE were detected in great-tailed grackles, also insectivorous. These concentrations were 3.2 μg/g from both a composite sample from Laguna Atascosa NWR and from the mouth of the Rio Grande. In general, concentrations of DDE in bird tissues have declined in Texas since 1965 (Mora 1995). Concentrations of DDE accumulated from Latin American sources in peregrine falcons have decreased, as well, between 1978 and 1994 (Henny et al. 1996).

DDE can adversely affect reproduction in a number of species including raptors (Anthony et al. 1993, Steidl et al. 1991) even at low levels. Screech owls (*Otus asio*) dosed with 2.8 μg/g DDE laid eggs 13% thinner than an untreated group (McLane and Hall 1972). An equivalent dose also resulted in eggshell-thinning in captive American kestrels (*Falco sparverius*) (Wiemeyer and Porter 1970). Lincer (1975) reported that a diet as low as 1 μg/g DDE for 2-3 months prior to nesting would cause 7% eggshell thinning in kestrels, one of the least sensitive members of the genus *Falco* (Fyfe et al. 1988). A diet of prey with 1.0 μg/g or greater may produce eggshell thinning in peregrine falcons (*Falco peregrinus*) (Enderson et al. 1982). In raptors, eggshell thinning of 18% or more precludes a self-sustaining population (Lincer 1975). The sensitivity of aplomado falcons to DDE is unknown, however, the highest concentration detected (0.25 μg/g) in this study is below dietary levels known to cause eggshell thinning in other members of the genus.

Although subadult aplomado falcons prey heavily on dragonflies (Chris Perez, pers. comm., 1994) and other insects, insectivorous birds represent a large portion of the adult diet, perhaps explaining why falcons tend to concentrate pesticide residues, a factor in their decline (Hector 1981). Insectivores may be as much as four times more contaminated with DDE than omnivores (DeWeese et al. 1986, Enderson et al. 1982).

Since this study did not include a strictly insectivorous species, monitoring of insectivores in areas around nesting sites may be warranted.

Trace Elements

Bird livers were analyzed for a total of nineteen trace elements. Arsenic, barium, beryllium, nickel, and vanadium were below the detection limits for all samples. Results for the remaining trace elements are given in Table 3. Those elements that are at or near levels of concern are discussed below.

Cadmium

Cadmium residues were detected in all bird liver samples and concentrations ranged from 0.26 to 3.30 µg/g dw. Highest concentrations were present in the meadowlark composite sample from Laguna Atascosa NWR Site #2. Only 2% or less of cadmium is assimilated when ingested, but once bound, cadmium has a long half-life and therefore accumulates with age (Scheuhammer 1987, Furness 1996). In healthy populations of wild birds, cadmium in livers ranged from 0.1 to 32 µg/g ww (or ~ 0.3 to 96 µg/g dw) (Furness 1996). Passerines and birds of prey are at the low end of this range, followed by waders and waterfowl, and then seabirds which are at the high end of the range (Furness 1996). It is unlikely that the concentrations detected in bird livers in this study are causing reproductive impairment to the falcons.

Mercury

Mercury was not detected in mourning doves or northern bobwhites, but concentrations in livers of meadowlarks ranged from 0.24 to 1.04 µg/g dw. The highest level (1.04 µg/g dw) was detected in birds obtained from Laguna Atascosa NWR Site #2. Several studies have shown that low dietary levels may have adverse reproductive effects on birds. In breeding mallards *(Anus platyrhynchos)*, 3 µg/g dietary methylmercury resulted in a reduced number of eggs, reduced hatching success, and increased early mortality in chicks (Heinz 1974). Mercury concentrations as low as 1-1.2 µg/g dw in prey of common loons (*Gavia immer)* were associated with reduced clutch size, increased nest desertion and decline of nesting territories (Barr 1986). These are the lowest levels of mercury in prey that have been associated with reproductive anomalies in wildlife (Scheuhammer 1987). Eisler (1987), however, suggests that aquatic prey items should not exceed 0.33 µg/g dw for the protection of sensitive species. Sensitivities of birds to mercury varies widely and little information is available for birds of prey. However, the intestinal absorptive efficiency of inorganic mercury in kestrels, a species in the same genus as the aplomado, was four times greater than mallards (Serafin 1984).

One unhatched aplomado falcon egg from the 1995 nesting effort in Texas contained

1.53 µg/g dw mercury and an egg from the 1996 nesting attempt contained 4.1 µg/g dw mercury (Mora et al., in press, Miguel Mora, pers. comm., 1996). In a study by Fimreite (1971), unhatched pheasant eggs contained 0.5 to 1.5 µg/g mercury when parents were fed a diet containing methylmercury. Mercury concentration in the aplomado eggs were at or above this range. Residues in livers of willets (*Catoptrophorus semipalmatus*) from agricultural drains of the lower Laguna Madre averaged 2 to 3.4 µg/g dw mercury with a maximum of 17 µg/g dw (Custer and Mitchell 1991), indicating mercury exposure in the Lower Rio Grande Valley. Because two of eight composite prey samples were within the ranges associated with reproductive anomalies and the egg also contained residues of mercury, there may be some concern about reproductive or chronic effects in the aplomado falcon.

Selenium

Selenium residues in livers from this study ranged from 1.88 µg/g dw in mourning doves from La Selva Verde to 4.96 µg/g dw in both mourning dove and meadowlark from Site 2 on Laguna Atascosa NWR. These levels are about the same as those reported by King et al. (1995) in a similar aplomado falcon study conducted in potential reintroduction sites in Arizona.

A small amount of selenium is necessary in the diet of birds, but the range between sufficient selenium in the diet and harmful amounts is narrow (Heinz 1996, Eisler 1985). Selenium-induced toxicosis occurred in irrigation drainwater ponds in the San Joaquin Valley where liver concentrations averaged over 80 µg/g dw in aquatic birds (Ohlendorf et al. 1988). From a control site, liver concentrations averaged less than 6 µg/g dw. In this same area, selenium concentration in plants, invertebrates, and fish were 22-175 µg/g dw, causing severe reproductive impacts to aquatic birds; at the control site, levels ranged from 0.43 to 2.09 µg/g dw (Ohlendorf et al. 1986). In a laboratory study, mallards fed 10 µg/g as selenomethionine experienced reduced hatching success and largely teratogenic effects, whereas 10 and 25 µg/g as sodium selenite fed to mallards caused mainly embryotoxic effects (Heinz and Hoffman 1987). Since little is known about the chemical forms of selenium, what percentages are transferred to embryos, or the toxicity to embryos, Heinz (1996) bases the threshold level affecting avian reproduction at 3 µg/g (ww)in eggs and at 10 µg/g (ww) in livers for sublethal effects. Lemly (1996) ranks a diet of macroinvertebrates >5 µg/g selenium as a high risk for reproductive impairment in fish and aquatic birds. However, for predators, Weimeyer and Hoffman (1996) suggest that dietary levels should be less than 10 µg/g dw. Because selenium concentrations were below the dietary threshold suggested for predators, it is unlikely that selenium poses a risk to aplomado falcons within the study area. Without knowing the selenium sensitivity of this species, results are difficult to interpret with complete confidence.

RECOMMENDATIONS

In a study conducted in Arizona, prey items were examined in potential aplomado falcon reintroduction sites (King et al. 1995). Contaminant residues were lower than those in Texas with the exception of selenium, which were comparable. Therefore, with the availability of large areas of undeveloped land and low levels of contaminants, reintroduction within the historical range in Arizona as outlined in the recovery plan, in addition to Matagorda Island at the northern extreme of the range, should be considered. Monitoring of nest success and contaminant levels in addled eggs should be continued. Further studies to determine the source of mercury and to evaluate insectivorous bird species for DDE accumulation within feeding areas of nests, are also warranted.

ACKNOWLEDGEMENTS

Thanks to Jim Barrera, Teresa Barrera, Jerry Lee, Don Oliver, Steve Robertson, Tom Schultz and Tara Schultz for assistance with field work. Marie Fernandez (Laguna Atascosa National Wildlife Refuge) and Yvette Truitt (Lower Rio Grande Valley National Wildlife Refuge) were both very helpful with logistics. I am grateful to Chris Perez for his suggestions during the design and fieldwork for this study. Brenda Andrews, Teresa Barrera, Kirke King, and Tom Schultz reviewed this report and I greatly appreciate all of their constructive comments and suggestions.

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Table 1. Compounds and trace elements analyzed in aplomado falcon prey items from the Lower Rio Grande Valley, Texas, 1994.

AROMATIC HYDROCARBONS	ORGANOCHLORINES	ORGANOPHOSPHATES
1,2,5,6-dibenzanthracene	HCB	EPN
1,2-benzanthracene	PCB-total	acephate
1-methylnapthalene	alpha BHC	azinphos-methyl
1-methylphenanthrene	alpha chlordane	chlorpyriphos
2,3,5-trimethylnapthalene	beta BHC	coumaphos
2,6-dimethylnapthalene	cis-nonachlor	demeton
2-methylnapthalene	delta BHC	diazinon
C1 Fluoranthenes & Pyrenes	dieldrin	dichlorvos
C1-C4-chrysenes	endrin	dicrotophos
C1-C3-dibenzothiophenes	gamma BHC	dimethoate
C1-C3-fluorenes	gamma chlordane	disulfoton
C1-C4-napthalenes	heptachlor epoxide	ethoprop
C-C4-phenanthrene	mirex	famphur
acenapthalene	o,p'-DDD	fensulfothion
acenapthene	o,p'-DDE	fenthion
anthracene	o,p'-DDT	malathion
benzo(a)pyrene	oxychlordane	methamidophos
benzo(b)fluoranthene	p,p'-DDD	methyl parathion
benzo(e)pyrene	p,p'-DDE	mevinphos
benzo(g,h,i)perylene	p,p'-DDT	monocrotophos
benzo(k)fluoranthene	toxaphene	parathion
biphenyl	trans-nonachlor	phorate
chrysene		terbufos
dibenzothiophene		trichlofon
fluoranthene		
indeno(1,2,3,-cd)pyrene		
napthalene		
perylene		
phenanthrene		
pyrene		

ELEMENTS	
Aluminum	Magnesium
Arsenic	Manganese
Barium	Mercury
Boron	Molybdenum
Beryllium	Nickel
Cadmium	Selenium
Chromium	Strontium
Copper	Vanadium
Iron	Zinc
Lead	

Table 2. Organochlorine residues in potential prey items of aplomado falcon collected from the Lower Rio Grande Valley, Texas, 1994.

Site	Sample	*n*	Weight (g)	% moist	% lipid	µg/g p,p'-DDE wet wt.	µg/g p,p'-DDE dry wt.
LA* Site 1	cicadas	40-50	12.0	NA[1]	3.68	<0.01	NA[2]
LA Site 2	cicadas	40-50	14.1	NA[1]	4.28	0.01	NA[2]
La Selva Verde	cicadas	8	17.4	NA[1]	6.20	<0.01	NA[2]
LA Site 1	dragonflies	40-60	11.0	NA[1]	4.31	<0.01	NA[2]
LA Site 2	dragonflies	40-60	11.0	NA[1]	4.61	0.01	NA[2]
La Selva Verde	dragonflies	40-50	10.9	NA[1]	5.36	0.05	NA[2]
Willamar	dragonflies	30-40	8.7	NA[1]	5.19	0.01	NA[2]
LA Site 1	mourning dove	5	379.0	72.5	3.41	0.05	0.18
LA Site 2	mourning dove	5	458.0	70.5	5.47	0.03	0.10
La Selva Verde	mourning dove	5	424.0	72.0	2.25	0.10	0.36
Willamar	mourning dove	5	383.0	72.5	4.53	0.02	0.07
LA Site 1	meadowlark	5	311.0	74.5	2.99	0.04	0.16
LA Site 2	meadowlark	5	346.0	73.5	2.35	0.11	0.42
Willamar	meadowlark	5	399.0	72.5	3.00	0.25	0.91
La Selva Verde	bobwhite	5	321.0	73.5	3.58	0.02	0.08

*Laguna Atascosa NWR

[1]Insufficient sample to determine moisture content.

[2]Dry weight not determined.

Table 3. Trace element concentrations (µg/g, dry weight) in potential prey items of the aplomado falcon collected from the Lower Rio Grande Valley, Texas, 1994.

		Trace elements (µg/g dry weight)[1]													
Site and species	*N*	Al	B	Cd	Cr	Cu	Fe	Hg	Mg	Mn	Mo	Pb	Se	Sr	Zn
<u>LA* Site 1</u>															
Mourning Dove	5	5.73	<1.99	0.99	0.73	18.74	1135	<0.10	916.5	15.65	4.18	<0.99	2.44	0.38	170.5
Meadowlark	5	14.49	<1.97	1.98	<0.50	17.60	867	0.676	803.8	3.95	2.16	<0.99	3.57	1.59	87.7
<u>LA Site 2</u>															
Mourning Dove	5	7.22	2.32	1.25	<0.50	15.89	1042	<0.10	500.9	11.07	3.79	<0.99	4.96	0.20	174.5
Meadowlark	5	5.82	<1.99	3.30	0.56	22.60	1084	1.04	963.2	6.94	3.73	1.50	4.96	1.50	132.4
<u>La Selva Verde</u>															
Mourning Dove	5	7.38	2.10	2.14	1.06	17.24	1462	<0.10	790.0	12.10	3.73	1.48	1.88	0.56	123.3
Northern Bobwhite	5	8.53	<1.99	0.26	2.39	20.00	819	<0.10	845.8	17.38	9.94	<1.0	2.49	1.26	181.7
<u>Willamar</u>															
Mourning Dove	5	5.75	<2.00	0.98	1.45	16.45	1291	<0.10	735.2	12.59	3.90	<1.0	1.94	0.28	103.2
Meadowlark	6	<4.91	<1.96	0.99	0.80	17.68	1036	0.239	734.6	4.34	2.49	<0.98	4.34	0.31	103.1

*Laguna Atascosa NWR

[1]Arsenic, barium, beryllium, nickel, and vanadium were not detected in any samples.

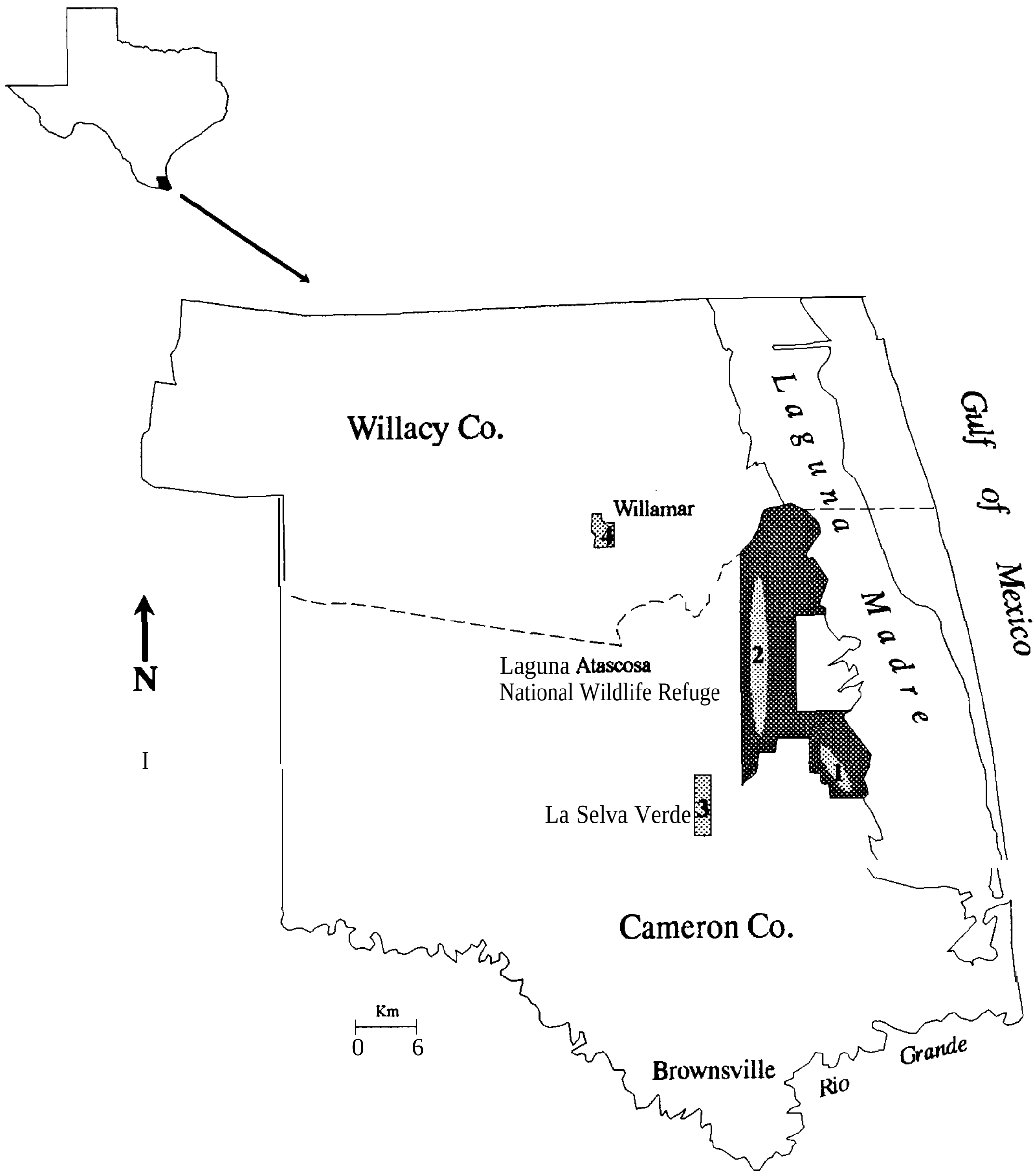

Figure 1. Location of collection sites for contaminant evaluation of potential aplomado falcon prey, 1994.